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AUTHOR Trenk, Barbara Scherr
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ABSTRACT

Designed for high school science teachers, the document warns of potential health threats of performing certain experiments and using certain chemicals or chemical combinations in their courses. Following a rationale for more carefully considering health dangers, the document gives suggestions on what can be done by teachers. Reports such as a survey by the Kentucky Labor Department, in which officials found that 30 percent of the state's four-year colleges and 5 percent of the high schools had one or more cancer-causing chemicals, are cited as sources of increasing concern. Sixteen carcinogens regulated by the Occupational Safety and Health Administration (OSHA) are listed, followed by a chart listing dangerous combinations of common school chemicals. Other cautions on handling chemicals are described and organic chemistry is discouraged at the high school level. Teachers are encouraged to re-evaluate laboratory equipment and chemicals and schools are urged to develop safe procedures for storage, use, disposal, and supervision by qualified personnel. (LH)

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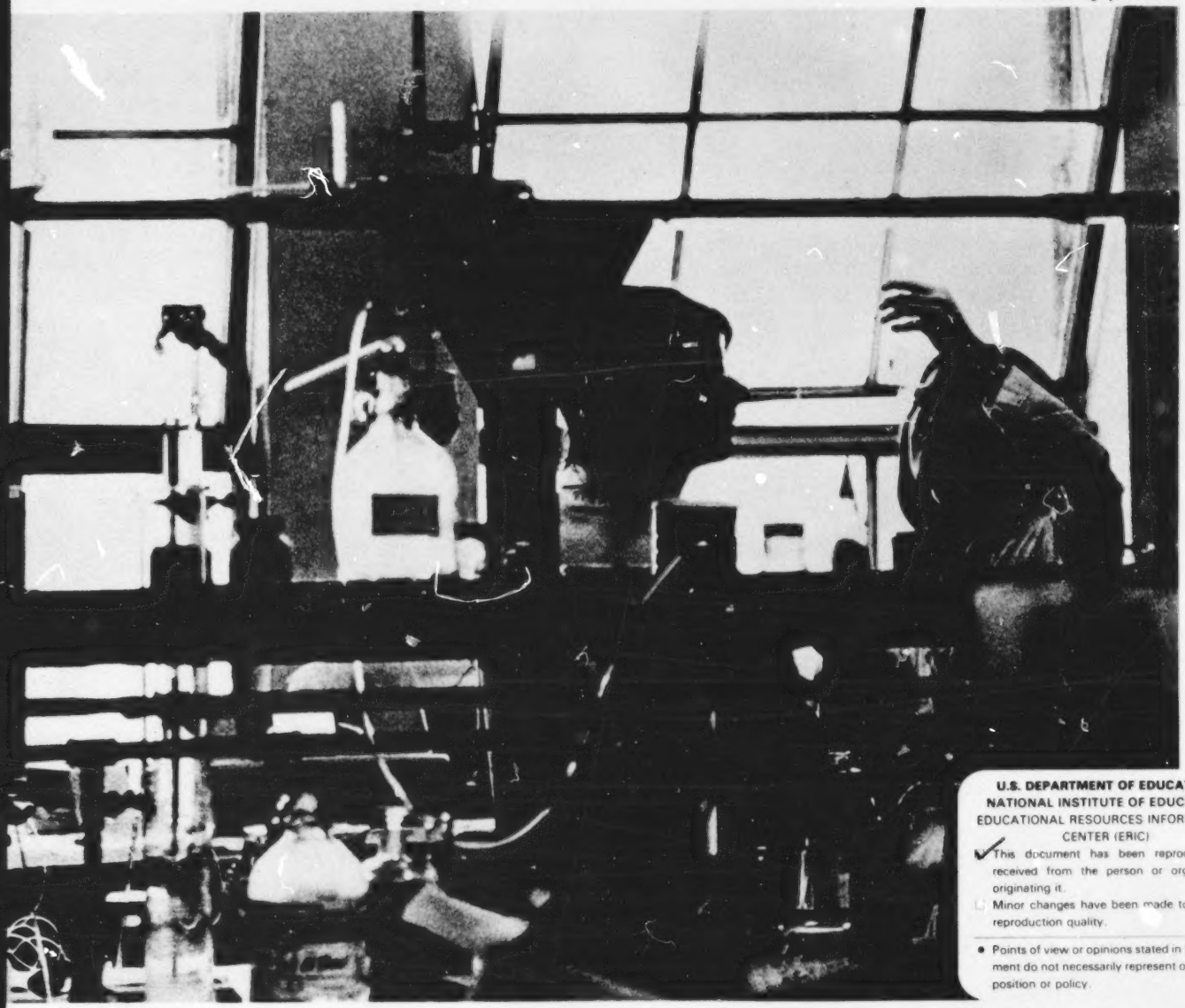

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HEALTH HAZARDS IN THE SCIENCE CLASSROOM

Barbara Scherr Trenk

Science teachers are becoming increasingly aware of the potential health threat of performing certain experiments and using certain chemicals or chemical combinations in their courses. An increasing number of diseases—some of them lung diseases—are found to come from exposure to chemicals used years earlier. Here is a rundown on some of the hazards and what can be done about them.

IS THE HIGH SCHOOL SCIENCE CLASSROOM hazardous to the students' health?

It can be.

Hazardous—including carcinogenic—chemicals have been found on some laboratory shelves, and science supervisors and instructors are becoming increasingly aware of the potential health threat of performing certain experiments and using certain chemicals or chemical combinations.

"Many modern laboratory chemicals are chemically complex and almost unbelievably sophisticated. Some are known to be toxic in themselves and lethal in combination with other substances. But the real danger lies in what we don't know about their long-range effect on the human body," says Donald A. Young, M.D., medical director of the American Lung Association. Some of these chemicals, according to Dr. Young, can cause such lung diseases as bronchitis and pneumonia. Still others are breathed in without apparent damage to the lungs, but with disease resulting in other parts of the body.

Danger to health—including potential lung disease—should be considered, along with traditional safety warnings of fire, explosion, and spillage in the science classroom. Here is some of the reasoning behind this statement:

- An increasing number of diseases are found to be derived from exposure to certain chemicals and substances, exposures that began—and often ended—years and sometimes decades before the onset of symptoms. School health officials and science teachers have a responsibility to check out the new information on potential dangers of substances used in the science classroom or laboratory.
- Many students who study biology or chemistry in high school make a career of laboratory work. A healthy respect for the potential exposures in this field can lead to a lifetime of good work habits and perhaps a longer, healthier life.
- Teachers and laboratory assistants are exposed to potential toxins more frequently than are students and for longer periods of time.
- Schools have been held liable by the courts for accidents resulting from negligence in safety procedures. If health problems are eventually traced back to classroom exposure, the schools may again be liable.
- The federally administered Occupational Safety and Health Administration (OSHA) does not have jurisdiction over public schools, but OSHA can investigate private institutions for violation of health and safety standards. In many of the 22 states where OSHA is administered at the state level, coverage is broader and may include public employees, making schools subject to inspection and penalties.

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What can be done

So what's a science teacher to do?

One thing science teachers and their supervisors are beginning to do is to discuss the problem. A conference, Health Hazards in the Science Classroom, sponsored by the American Lung Association of Nassau-Suffolk (Long Island, N.Y.) and the Nassau County Board of Cooperative Educational Services, provided an introduction to the problems. Susan M. Daum, M.D., and Jeanne M. Stellman, Ph.D., co-authors of *Work Is Dangerous to Your Health,** were the main resource people. Dr. Daum is an in-

*Published by Vintage Books, a division of Random House.

What chemicals are students using in their experiments? Many state education departments are ordering certain materials off the shelves.

ternist in the Department of Environmental Medicine at Mt. Sinai Medical Center, New York City, and Dr. Stellman is chief of occupational health and toxicology at the American Health Foundation, New York City.

Changes have already been made in some classrooms as a result of discussions at the conference, and science supervisors have requested similar programs on both a county and state-wide basis.

Many school systems are now including information about possible health hazards from science experiments in their safety bulletins. The National Science Teachers Association, located in Washington, D.C.,† is in the final stages of developing two new safety booklets, one for elementary school teachers and the other for high school teachers. The booklets will incorporate the latest information on health hazards of certain chemicals and chemical reactions, as well as general safety precautions for handling materials in school laboratories. The booklets will also cover suggestions for alternative chemicals and experiments for the curriculum, including the substitution of filmed experiments for dangerous demonstrations. In addition, the Council of State Supervisors of Science, an NSTA affiliate, is preparing a safety training course for science teachers, with OSHA support and cooperation.

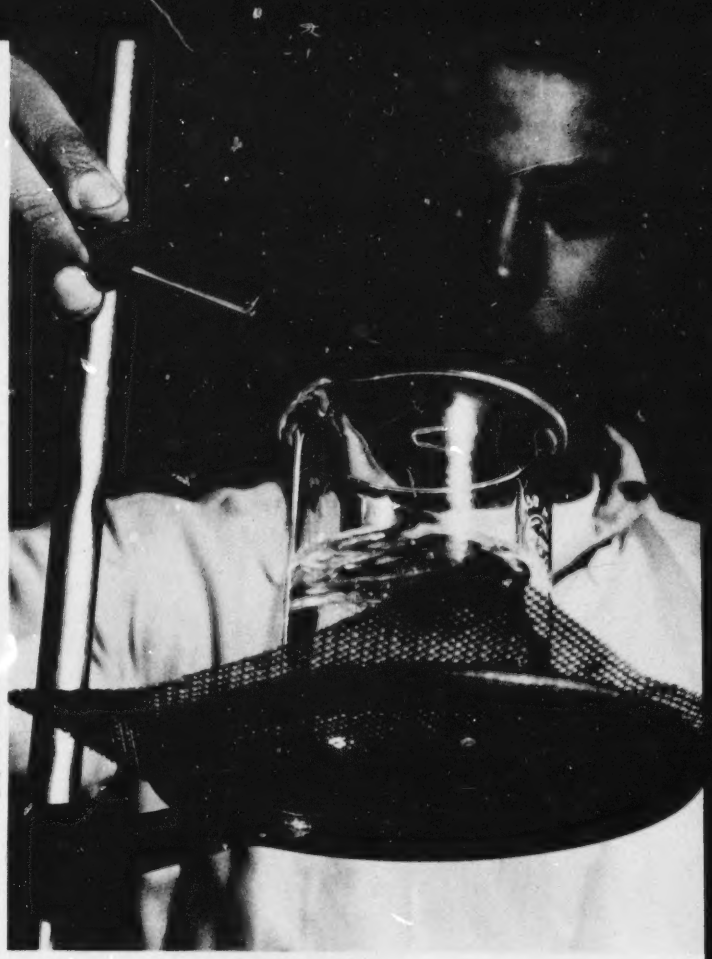
High school and college journals for science teachers are also good sources of information on hazardous chemicals. In addition, teachers can draw upon the resources of industrial hygiene and occupational health books in college and medical libraries. Other sources are federal and state Occupational Safety and Health Administration offices (part of the Department of Labor), local health departments, the air pollution control unit of environmental control departments, local branches of the American Lung Association, and some union offices.

Carcinogens on laboratory shelves

Experts agree that certain chemicals have no place on the shelves of a high school laboratory. Many state education or OSHA departments have ordered that all of 16 known carcinogens (see Figure 1) be removed from high school and college classroom shelves. These are substances for which the recommended exposure level is essentially zero.

A survey by Kentucky Labor Department officials found that 90% of the 41 four-year colleges and universities in that state had one or more of these cancer-causing chemicals, as did 5% of the high schools, according to a

†For information on the availability of the two new safety booklets, write: National Science Teachers Association, 1742 Connecticut Avenue, N. W. Washington, D.C.20009.



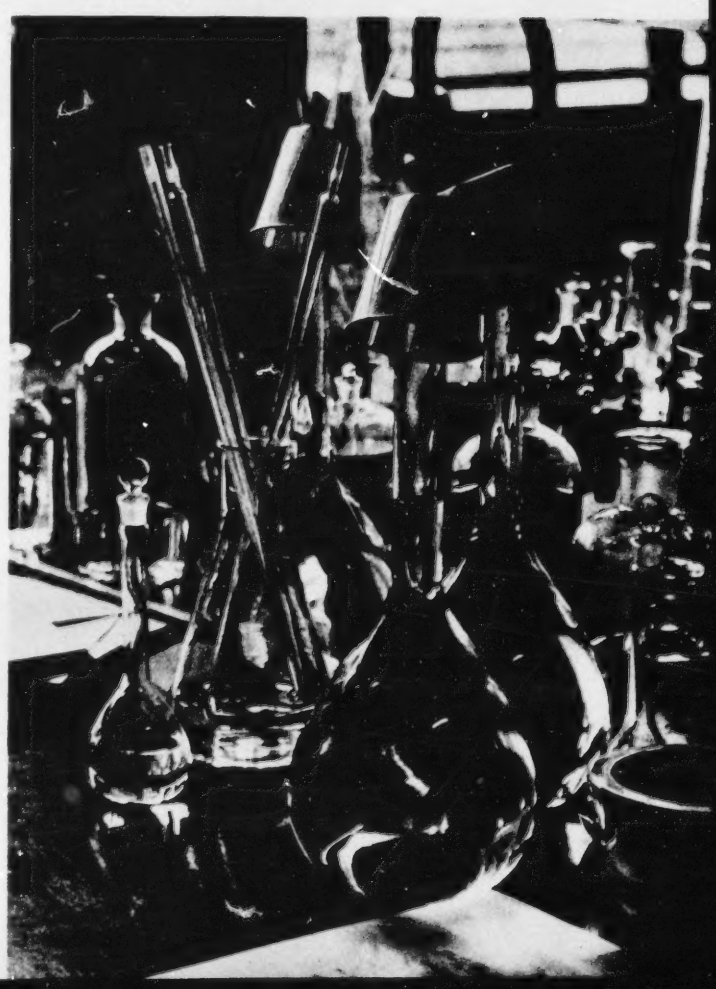


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Figure 1
The 16 carcinogens regulated by OSHA

OSHA has prepared regulatory standards for the following carcinogens:

4-Nitrobiphenyl (4-NBP)
Alpha-Naphthylamine (1-NA)
4, 4'-Methylene bis (2-chloroaniline) (MOCA)
Methyl chloromethyl ether (CMME)
3, 3' Dichlorobenzidine (and its salts)
Bis chloromethyl ether (BCME)
Beta-Naphthylamine (2-NA)
Benzidine
4-Aminodiphenyl
Ethyleneimine (EL)
Beta-Propiolactone (BPL)
2-Acetylaminofluorene
4-Dimethylaminoazobenzene (DAB)
N-N' trosodimethylamine (DMN)
Vinyl chloride
Asbestos

A list of alternate names, prepared by Dr. J. B. Block, is available from your lung association.

report in the September 1976 *Journal of College Science Teaching*.

Arizona, Oregon, Washington, and Utah authorities reported their own scattered instances of finding carcinogens in high school or college chemistry labs, with few or no restrictions placed on them, according to an article in the December 13, 1975, *The National Observer*.

School personnel wishing to survey their districts for the presence or use of these substances should be aware of two things, advises J. Bradford Block, M.D., medical consultant to Kentucky's Department of Labor. The first is that each of the 16 carcinogens is known by a variety of names, so that even the knowledgeable chemistry teacher may need a complete listing to do a thorough search of the science department shelves. (Dr. Block's long list of alternate names appeared in the *Journal of College Science Teaching* article mentioned above. Reprints are available as indicated in Figure 1.) The second consideration is that improperly packaged and disposed of carcinogens may be even more dangerous than they were on the schoolroom shelves. Dr. Block suggests that school officials consult their local health department before disposing of such materials.

The most frequently found chemicals on the Kentucky list was benzidine. The American Conference of Government Industrial Hygienists recommends "no exposure or contact by any route, respiratory, skin, or oral, as detected

Figure 2: DANGEROUS COMBINATIONS OF COMMON SCHOOL CHEMICALS

Many substances which are not harmful themselves can become dangerous — toxic, explosive or flammable — when exposed to other materials. Care should be exercised in disposing of chemicals, as well as while using them, to see that hazardous combinations are not mixed.

The following combinations are among those described as incompatible in *"Safety Alert,"* published by the Nassau County Science Supervisors Association. (Note that some chemicals *not* recommended for classroom use have been included because teachers who do continue to use them should be aware of the potential hazards.)

Compound	***Should not come in contact with:***
Acetic acid	Nitric acid, peroxides, permanganates, ethylene glycol, hydroxyl compounds
Alkali metals, e.g., sodium and potassium	Carbon tetrachloride, carbon dioxide, water
Alkali metals, e.g., powdered aluminum and magnesium	Carbon tetrachloride, other hydrocarbons, halogens, carbon dioxide
Ammonium nitrate	Acids, inflammable liquids, metal powders, sulfur, chlorates, any finely divided organic or combustible substance
Bromine, chlorine	Ammonia, petroleum gases, hydrogen, sodium, benzene, finely divided metals
Chlorates	Ammonium salts, acids, metal powders, sulfur, any finely divided organic or combustible substance
Hydrocarbons, e.g., propane, benzene, and gasoline	Fluoride, chlorine, bromine, sodium peroxide
Hydrogen peroxide	Most metals and their salts, alcohols, organic substances, any inflammable substance
Hydrogen sulfide	Oxidizing gases, fuming nitric acid
Iodine	Acetylene, ammonia, hydrogen
Mercury	Acetylene, ammonia
Nitric acid (concentrate)	Acetic acid, hydrogen sulfide, inflammable liquids and gases
Potassium chlorate	Sulfuric and other acids, any organic substance
Potassium permanganate	Sulfuric acid, glycerine, ethylene glycol
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, carbon disulfide, glycerine, ethylene glycol, ethyl acetate.
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate, similar compounds of other light metals.

NOTE: There are thousands of incompatible chemicals. The above items are but a few of those most commonly found in high schools. Teachers who regularly handle less common materials should have in their possession for constant reference:
MANUAL OF HAZARDOUS CHEMICAL REACTIONS (latest edition), National Fire Protection Association, 60 Batterymarch St. Boston, Ma. 02110.

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by the most sensitive methods." Benzidine has been used in schools primarily as an indicator in quantitative analysis and to stain slides in biology classes.

After Dr. Block's effort to remove these carcinogens from the schools was reported in *The National Observer*, he learned about a Chicago chemistry major who had developed leukemia while in college; her physician attributed her disease to exposure to benzidine in the laboratory.

Other materials that are being excluded

Carcinogens are not the only substances that are being taken off the shelves in some concerned school districts.

Although there may still be some science teachers who allow their students to play with balls of mercury to demonstrate the physical properties of this liquid metal, other schools are removing it completely from their laboratories because of the potential damage to the central nervous system from mercury vapors. One school system even sold its supply to a plumbing firm and stopped using mercury thermometers. This turned out to be good economics as well as good health. Alcohol thermometers are less expensive and do not pose a chemical hazard if the instrument breaks. In the same district, junior high school students who used to construct mercury barometers are now building instruments made without liquid.

Formaldehyde, the preservative traditionally used in the biology classroom, is being eliminated in many schools. Teachers can order an equally effective substitute by requesting "non-toxic preservative" (sold under several trade names‡) and avoid the irritation to the respiratory system and eyes often caused by formaldehyde. These reactions probably do not become serious health hazards, says Dr. Daum, because the unpleasant odor discourages great exposure. Formaldehyde, however, can present a

‡Among the trade names for formaldehyde substitutes are Bio-Penn, Nasco-Guard Preservative, Di/Sekto, Poly Di/Sekto.

Not only is the choice of chemicals used in the high school laboratory important, but the concentrations should be watched. Goggles are worn when working with hot solids and liquids or with caustic materials.

serious hazard if it is mixed with an acid solution. It then can produce bischloromethyl ether, a known carcinogen, warns Dr. Stellman.

"Teachers must exercise caution when students request materials for special demonstration projects or science fair entries," advises Bernard M. McFadden, director of publications for the Nassau County Science Supervisors Association and a board member of the National Science Supervisors Association. Sometimes, a well-meaning instructor will inadvertently order a substance for an ambitious youngster's project that would not normally have a place on a high school laboratory's shelf.

Other cautions in handling chemicals

The alert teacher can give a meaningful lesson to his or her students when substituting a less harmful chemical for a potentially hazardous one. Unfortunately, there are no consistent rules for the substitution of one chemical for another. If the teacher does not know which chemical can replace a harmful one, he or she should consult with a colleague who has more experience in a particular specialty, or with the department chairman or science supervisor. Members of the chemistry faculty at a nearby state university are also an important resource, says Dr. Block of Kentucky's Department of Labor.

Not only is the choice of chemicals to be used in the high school laboratory important, but the concentrations should also be watched. "Do not perform experiments that require concentrated acids," recommends a college professor, noting the dangers of burns and explosions. "If di-

Photos: Freelance Photographers Guild

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The chemistry teacher is giving a meaningful lesson to students in substituting a less harmful chemical for a potentially hazardous one.

lute solutions won't work, don't do the experiment."

Disposal of laboratory materials is also a potential hazard.

Adelphi University in Nassau County has instituted a solvent recovery program. Instead of pouring solvents down the drain, students collect the liquids at the close of a laboratory period and seal them in bottles and cans for disposal by a commercial service. The school spends only $200 per year to dispose of the waste solvents produced by 1,000 chemistry students, and it eliminates a potential health problem within the laboratory building, as well as the environmental problem of toxic waste that would eventually be piped to the nearby ocean.

Organic chemistry for high school students?

Organic chemistry, which was formerly taught only at the college level, is now being taught as an advanced course in some high schools. Chemicals used in this course are the source of many potential health hazards from exposure to toxic substances. Analytic chemistry has been suggested as a better choice for an advanced high school chemistry course.

Chemist Jeanne M Stellman has suggested that for both health and academic reasons, organic chemistry not be part of a high school curriculum. Not only do the laboratory experiments involve the use of such hazardous materials as carbon tetrachloride (a carcinogen that can cause other liver damage as well) and benzene (it can cause leukemia), but the students' time can perhaps be better spent on developing a better understanding of more fundamental areas of the subject, according to Dr. Stellman.

Equipment in science laboratories

The health hazard of exposure to asbestos in industry and in the construction of schools and public buildings has made headlines in the past few years, but little has been said publicly about the use of smaller asbestos products.

The New York State Bureau of Science Education recommends using non-asbestos substitutes whenever possible. Items such as asbestos hot pads and asbestos fire blankets are now being eliminated in some schools. Ordinary kitchen hot pads of aluminum or ceramic are adequate for resting hot glassware; wool fire blankets are sufficiently fireproof to smother a classroom laboratory fire and cost no more than their asbestos counterparts.

Frequent targets of blame for potentially unhealthy exposures in the science classroom are the often malfunctioning or improperly vented hoods, according to science teachers attending the conference. Even new, expensive equipment which is supposed to take off fumes often is not properly designed or installed.

Several science supervisors in the Nassau-Suffolk area have suggested that, with careful evaluation of experiments performed in chemistry laboratories, hoods need to serve only as a supplemental ventilation system, especially at this time, when school budgets are tight and replacement or extensive repairs are unlikely to be approved. If highly toxic gases are not included in the ingredients or if toxic

gases will not result from a laboratory experiment, there is no great cause for concern about the quality of existing hoods.

Schools customarily provide certain safety equipment and countermeasures for science laboratory work, equipment such as eye baths, showers, and fire blankets. In addition, schools should take certain precautions to insure rapid action in case of adverse reaction to a chemical or accidental exposure to toxic or irritating substances, recommends Rosalie A. Cohen, administrator of school health services for the Nassau (N.Y.) County Board of Cooperative Educational Services. The telephone number of the nearest poison center should be posted in the school nurse's office and also near the telephone closest to the laboratory. It has also been suggested that the antidotes to substances regularly used in the laboratory be placed on file with the school nurse or in the classroom.

In conclusion

As noted earlier, the National Science Teachers Association expects its forthcoming safety bulletins to give the teacher more guidance on chemical health hazards.

Guidelines currently exist in some state and local school systems. In the absence of such guidelines, the following recommendation would appear to be minimal: *An inventory should be made to uncover hazardous chemicals. Unnecessary ones should be discontinued; any retained should be labeled as hazardous. Schools should develop safe procedures for storage, use, disposal, and supervision by qualified personnel.*

Dr. Block discussed the problem of cancer-causing materials with several chemistry professors, who unanimously suggested the total elimination of all cancer-causing materials from any high school laboratory. To the extent practical, the same rule might well be applied to other chemicals hazardous to health in the high school. «

Barbara Scherr Trenk is public relations consultant for the American Lung Association of Nassau-Suffolk; she previously served as public relations associate for the New York Lung Association. Ms. Trenk recently completed a Master's degree in Health Care Administration. She has a strong interest in the social and political aspects of disease prevention and health care delivery.

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